



US007952342B2

(12) **United States Patent**
Satoh

(10) **Patent No.:** **US 7,952,342 B2**
(45) **Date of Patent:** **May 31, 2011**

(54) **CONSTANT CURRENT SOURCE APPARATUS**

(75) Inventor: **Hiroyuki Satoh**, Tokyo (JP)

(73) Assignee: **Advantest Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 343 days.

(21) Appl. No.: **11/873,425**

(22) Filed: **Oct. 17, 2007**

(65) **Prior Publication Data**

US 2009/0284236 A1 Nov. 19, 2009

(51) **Int. Cl.**

G05F 1/46 (2006.01)
G05F 1/56 (2006.01)
G05F 1/563 (2006.01)

(52) **U.S. Cl.** **323/317**; 323/314

(58) **Field of Classification Search** 323/311-315,
323/317

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,004,158 A * 1/1977 Morgan 327/87
4,540,953 A * 9/1985 Togari et al. 330/284

5,796,276 A * 8/1998 Phillips et al. 327/108
5,798,723 A * 8/1998 Fong 341/136
6,201,380 B1 * 3/2001 Tsujino et al. 323/313
6,597,240 B1 * 7/2003 Walburger et al. 330/10

* cited by examiner

Primary Examiner — Gary L Laxton

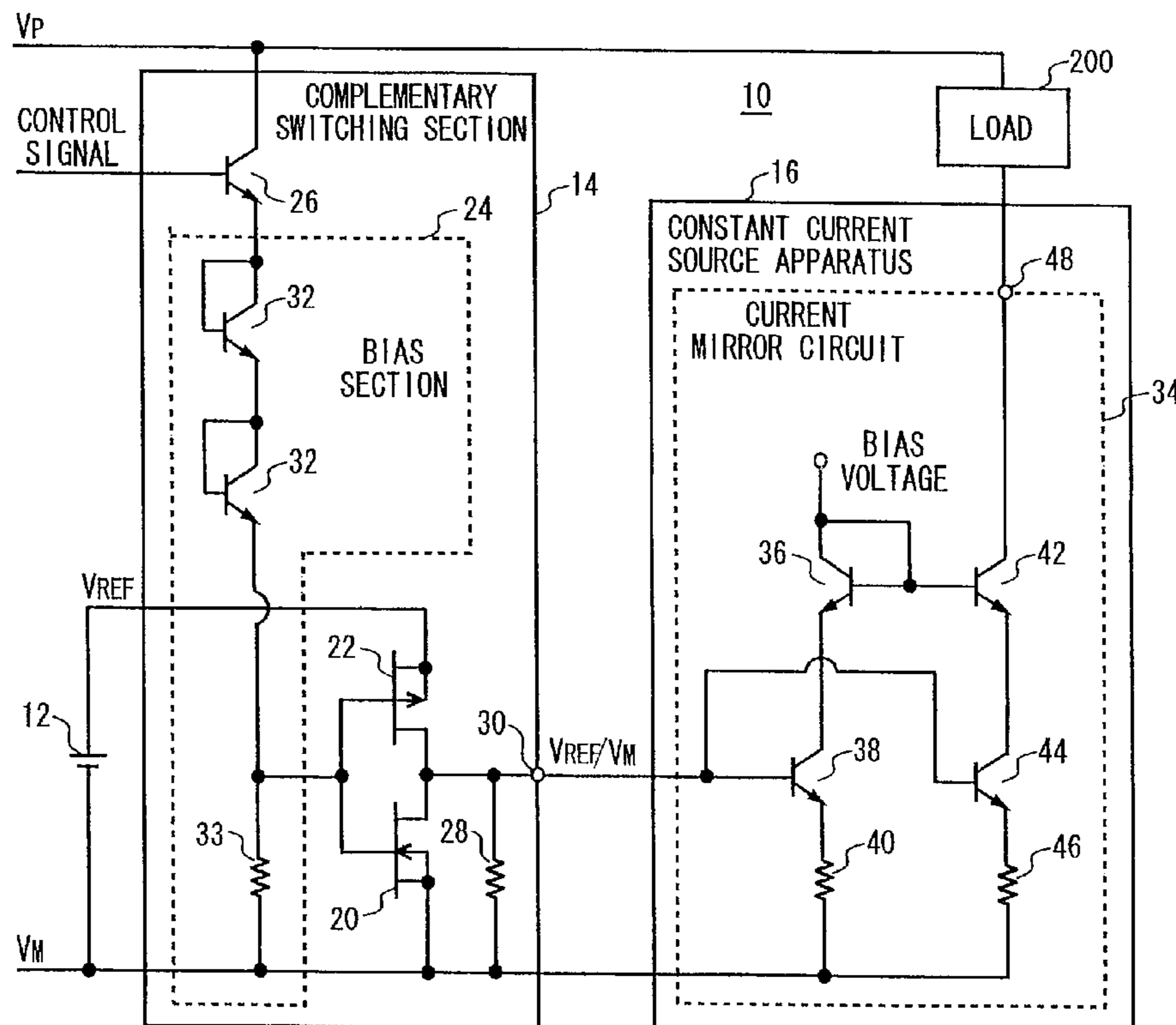
Assistant Examiner — Nusrat J Quddus

(74) *Attorney, Agent, or Firm* — Chen Yoshimura LLP

(57) **ABSTRACT**

A constant current source apparatus is provided that includes a complementary switching section that selectively outputs a reference voltage or a driving voltage according to a control signal and a constant current source circuit that causes a constant current determined by the reference voltage to flow to a load in a case where the reference voltage is received from the complementary switching section and cuts off the current flowing to the load in a case where the driving voltage is received from the complementary switching section. The complementary switching section includes a first FET in which one of either a source or a drain is connected to the driving voltage, the other source or drain is connected to an output end of the complementary switching section, and a gate receives the voltage according to the control signal and a second FET that switches to an opposite polarity of the first FET in which one of either a source or a drain is connected to the reference voltage, the other source or drain is connected to the output end of the complementary switching section, and a gate receives the voltage according to the control signal.

16 Claims, 2 Drawing Sheets



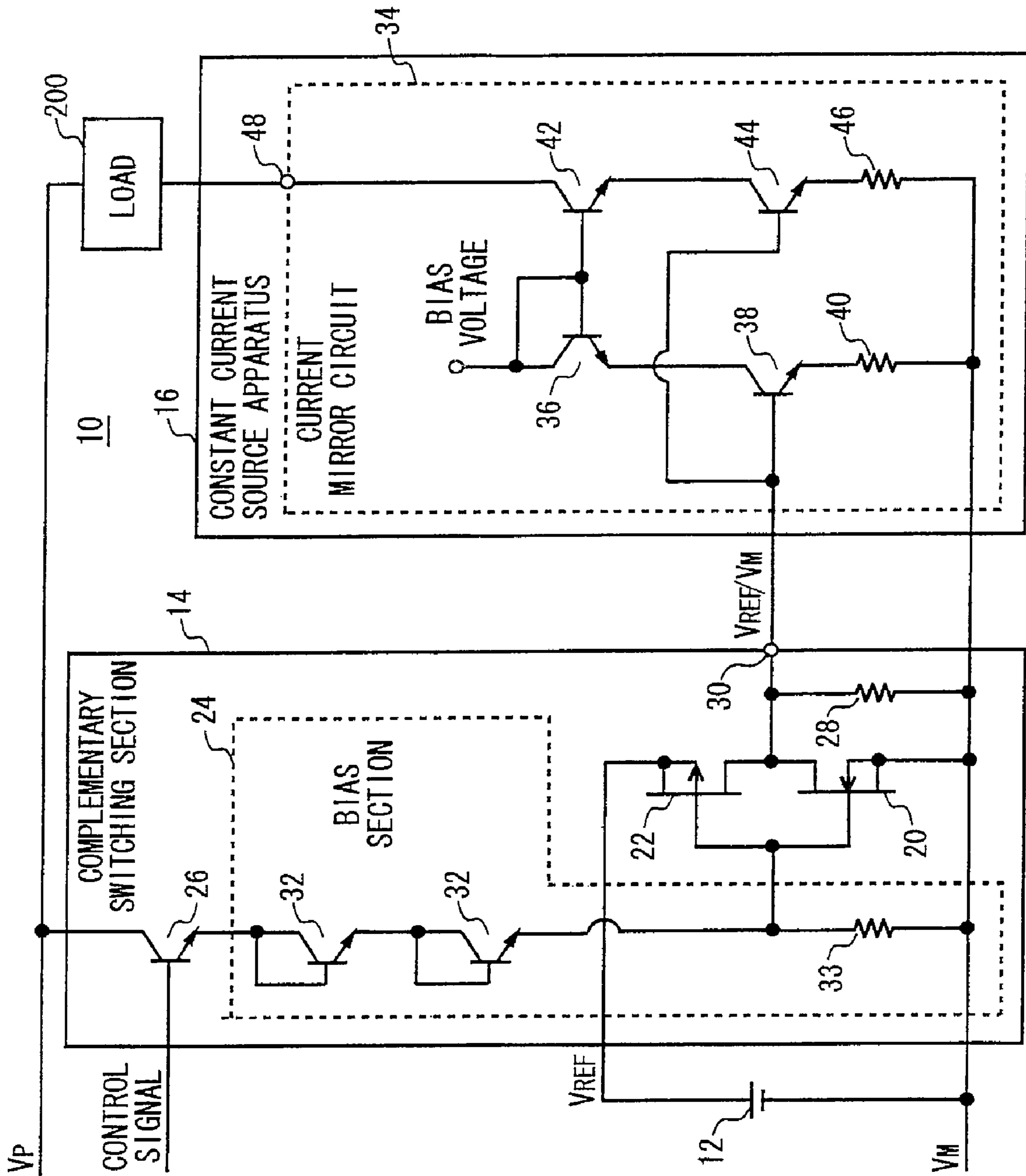


FIG. 1

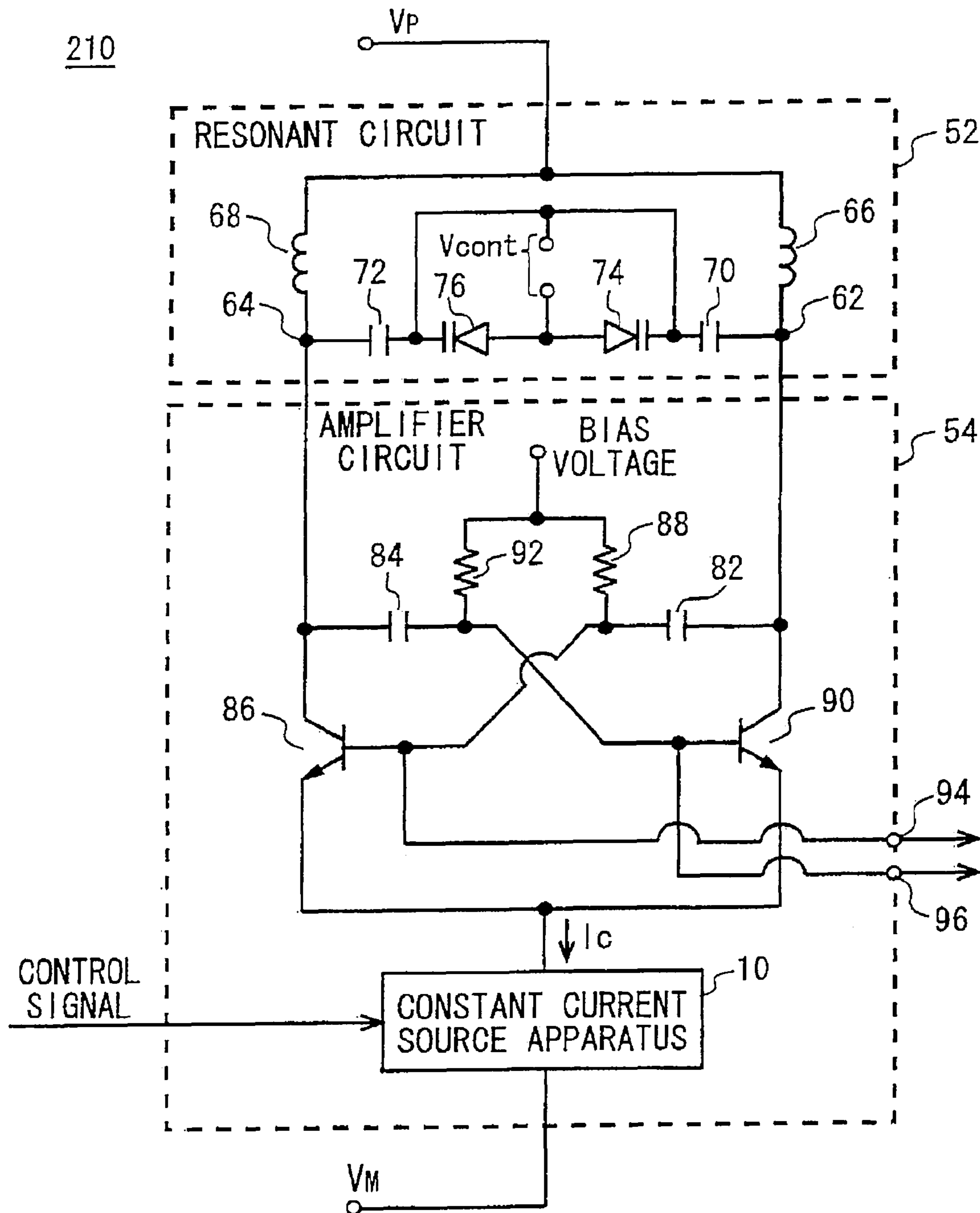


FIG. 2

CONSTANT CURRENT SOURCE APPARATUS

BACKGROUND

1. Technical Field

The present invention relates to a constant current source apparatus and, more particularly, the present invention relates to a constant current source apparatus that turns a current flowing to a load on or off.

2. Related Art

A constant current source apparatus such as a current mirror circuit or the like is known. The constant current source apparatus can cause a constant current to flow to a load regardless of variance of impedance of the load.

A control apparatus controlling operation of the constant current source apparatus must stop a supply of bias voltage to the constant current source apparatus in a case where the constant current source apparatus is turned off. Accordingly, the control apparatus is unable to turn the constant current source apparatus on or off by supplying a signal different than an operating voltage (a logic signal, for example) to the constant current source apparatus.

SUMMARY

Therefore, it is an object of an aspect of the present invention to provide a constant current source apparatus, which is capable of overcoming the above drawbacks accompanying the related art. The above and other objects can be achieved by combinations described in the independent claims. The dependent claims define further advantageous and exemplary combinations of the present invention.

According to a first aspect related to the innovations herein, one exemplary apparatus may include a constant current source apparatus. The constant current source apparatus includes a complementary switching section that selectively outputs a reference voltage or a driving voltage according to a control signal and a constant current source circuit that causes a constant current determined by the reference voltage to flow to a load in a case where the reference voltage is received from the complementary switching section and cuts off the current flowing to the load in a case where the driving voltage is received from the complementary switching section.

The summary clause does not necessarily describe all necessary features of the embodiments of the present invention. The present invention may also be a sub-combination of the features described above. The above and other features and advantages of the present invention will become more apparent from the following description of the embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a configuration of a negative FET 20 together with a load 200 according to an embodiment of the present invention.

FIG. 2 shows a circuit configuration of a voltage control oscillator 210 according to the present embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described. The embodiment does not limit the invention according to the claims, and all the combinations of the fea-

tures described in the embodiment are not necessarily essential to means provided by aspects of the invention.

FIG. 1 shows a configuration of a constant current source apparatus 10 together with a load 200 according to an embodiment of the present invention. The constant current source apparatus 10 causes a constant current to flow to the load 200 in a case where a control signal indicating "on" is supplied from an external section. Furthermore, the constant current source apparatus 10 cuts off the current flowing to the load 200 in a case where a control signal indicating "off" is supplied from the external section. In other words, the constant current source apparatus 10 sets the current flowing to the load 200 to be zero in a case where the control signal indicating "off" is supplied from the external section.

The constant current source apparatus 10 is provided with a reference voltage generation section 12, a complementary switching section 14, and a constant current source circuit 16. The reference voltage generation section 12 generates a reference voltage V_{REF} . For example, the reference voltage generation section 12 may be a bandgap reference circuit that generates the reference voltage V_{REF} .

For example, the bandgap reference circuit uses a diode supplied with a forward bias to generate the reference voltage V_{REF} . The bandgap reference circuit negates forward voltage variance according to a negative temperature coefficient of the diode by generating a voltage having a positive temperature coefficient. Accordingly, the bandgap reference circuit can output the constant reference voltage V_{REF} in changing temperatures.

The complementary switching section 14 selectively outputs the reference voltage V_{REF} or a driving voltage (in the present embodiment, a negative driving voltage V_M) according to a control signal. The driving voltage may be a positive driving voltage V_P or a ground potential instead of the negative driving voltage V_M .

Specifically, the complementary switching section 14 outputs the reference voltage V_{REF} in a case where a control signal indicating "on" is supplied from an external section. Furthermore, the complementary switching section 14 outputs the negative driving voltage V_M in a case where a control signal indicating "off" is supplied from the external section.

In the present embodiment, the complementary switching section 14 includes a negative FET 20, a positive FET 22, a bias section 24, a switching circuit 26, and a protection resistor 28. One of either a source or a drain of the negative FET 20 is connected to the negative driving voltage V_M and the other source or drain is connected to an output end 30 of the complementary switching section 14. The negative FET 20 receives voltage at a gate according to the control signal.

The negative FET 20 may be an n-type MOSFET, for example. In such a case, the source of the negative FET 20 is connected to the negative driving voltage V_M and the drain is connected to the output end 30.

One of either a source or a drain of the positive FET 22 is connected to the reference voltage V_{REF} and the other source or drain is connected to the output end 30 of the complementary switching section 14. The positive FET 22 receives voltage at a gate according to the control signal and switches polarity with the negative FET 20.

For example, the positive FET 22 may be a p-type MOSFET. In such a case, the source of the positive FET 22 is connected to the reference voltage V_{REF} and the drain is connected to the output end 30.

The bias section 24 supplies to the gate of the negative FET 20 and the positive FET 22 a first voltage that turns on the negative FET 20 and turns off the positive FET 22 (a voltage sufficiently higher than the negative driving voltage V_M) or a

second voltage that turns off the negative FET **20** and turns on the positive FET **22** (a voltage sufficiently lower than the reference voltage V_{REF}). For example, the bias section **24** may include one or more transistors **32** having a diode-connection and a bias input resistor **33**. The one or more transistors **32** are connected serially between the positive driving voltage V_P and the gate of the negative FET **20** and the positive FET **22**. The bias input resistor **33** is connected between the gate of the negative FET **20** and the positive FET **22** and the negative driving voltage V_M . The bias section **24** having such a configuration can supply a first voltage and a second voltage to the gate of the negative FET **20** and the positive FET **22**.

The switching circuit **26**, according to the control signal, switches between supplying the first voltage to the gate of the negative FET **20** and the positive FET **22** and supplying the second voltage to the gate of the negative FET **20** and the positive FET **22**. For example, the switching circuit **26** may be an npn transistor connected serially in the bias section **24** between the positive driving voltage V_P and the gate of the negative FET **20** and the positive FET **22**. In a case where a control signal indicating “on” is supplied from the external section, the switching circuit **26** causes the current flowing to the bias input resistor **33** to be sufficiently small, so that the second voltage (a voltage sufficiently lower than the reference voltage V_{REF}) is provided to the gate of the negative FET **20** and the positive FET **22**. Furthermore, in a case where a control signal indicating “off” is supplied from the external section, the switching circuit **26** causes the current flowing to the bias input resistor **33** to be sufficiently large, so that the first voltage (a voltage sufficiently higher than the negative driving voltage V_M) is provided to the gate of the negative FET **20** and the positive FET **22**.

The protection resistor **28** is connected between the output end **30** of the complementary switching section **14** and the negative driving voltage V_M . Even in a case where both the negative FET **20** and the positive FET **22** are momentarily turned off, the protection resistor **28** described above can set the negative driving voltage V_M without making the potential of the output end **30** inconsistent.

In a case where a control signal indicating “on” is supplied from the external section, the complementary switching section **14** configured as described above turns on the positive FET **22** and turns off the negative FET **20**. Furthermore, in a case where a control signal indicating “off” is supplied from the external section, the complementary switching section **14** turns on the negative FET **20** and turns off the positive FET **22**. Accordingly, the complementary switching section **14** can selectively output the reference voltage V_{REF} or the negative driving voltage V_M from the output end **30**.

The constant current source circuit **16** receives the reference voltage V_{REF} or the negative driving voltage V_M output from the complementary switching section **14**. In a case where the reference voltage V_{REF} is received from the complementary switching section **14**, the constant current source circuit **16** causes a current determined by the reference voltage V_{REF} to flow to the load **200**. In a case where the negative driving voltage V_M is received from the complementary switching section **14**, the constant current source circuit **16** cuts off the flow of current to the load **200**.

For example, the constant current source circuit **16** may include a current mirror circuit **34**. The current mirror circuit **34** may include, for example, a control transistor **36**, a first bias transistor **38**, a first reference resistor **40**, a current source transistor **42**, a second bias transistor **44**, and a second reference resistor **46**.

A base-collector junction of the control transistor **36** is a short-circuit. In other words, the control transistor **36** is a diode connection. Furthermore, a collector of the control transistor **36** is connected to a prescribed bias voltage.

A collector of the first bias transistor **38** is connected to an emitter of the control transistor **36** and an emitter of the first bias transistor **38** is connected to the negative driving voltage V_M via the first reference resistor **40**. The first reference resistor **40** has a predetermined resistance value. Furthermore, a base of the first bias transistor **38** is supplied with the reference voltage V_{REF} or the negative driving voltage V_M from the complementary switching section **14**.

In other words, the first bias transistor **38** is connected between the emitter of the control transistor **36** and the negative driving voltage V_M . In a case where the reference voltage V_{REF} is received from the complementary switching section **14**, the first bias transistor **38** generates a bias determined by the reference voltage V_{REF} . Furthermore, in a case where the negative driving voltage V_M is received from the complementary switching section **14**, the first bias transistor **38** becomes open.

The current source transistor **42** may be a transistor having generally the same type of characteristics as the control transistor **36**. A base of the current source transistor **42** is connected to the base of the control transistor **36**. A collector of the current source transistor **42** is connected to the load **200** via the load connection end **48**. A collector-emitter junction of the current source transistor **42** described above is serially connected to the load **200**, so that the current flowing to the load **200** flows to the collector-emitter junction.

A collector of the second bias transistor **44** is connected to the emitter of the current source transistor **42** and an emitter of the second bias transistor **44** is connected to the negative driving voltage V_M via the second reference resistor **46**. The second reference resistor **46** includes a resistance value proportional to the first reference resistor **40**. For example, the second reference resistor **46** may have the same resistance value as the first reference resistor **40**. Furthermore, a base of the second bias transistor **44** is supplied with the reference voltage V_{REF} or the negative driving voltage V_M from the complementary switching section **14**.

In other words, the second bias transistor **44** is connected between the emitter of the current source transistor **42** and the negative driving voltage V_M . In a case where the reference voltage V_{REF} is received from the complementary switching section **14**, the second bias transistor **44** generates a bias determined by the reference voltage V_{REF} . Furthermore, in a case where the negative driving voltage V_M is received from the complementary switching section **14**, the second bias transistor **44** becomes open.

In the current mirror circuit **34** configured as described above, in a case where the reference voltage V_{REF} is received from the complementary switching section **14**, the collector-emitter junctions of the first bias transistor **38** and the second bias transistor **44** become a predetermined bias voltage. Therefore, a predetermined fixed collector current flows to the control transistor **36**. Then, because the control transistor **36** and the current source transistor **42** function as current mirrors, a collector current proportional to the collector current flowing to the control transistor **36** flows to the current source transistor **42**. For example, a collector current that is the same as the collector current flowing to the control transistor **36** flows to the current source transistor **42**.

Furthermore, in the current mirror circuit **34** described above, in a case where the negative driving voltage V_M is received from the complementary switching section **14**, the collector-emitter junctions of the first bias transistor **38** and

5

the second bias transistor **44** become open. Therefore, a collector current of the control transistor **36** becomes zero, which causes the collector current of the current source transistor **42** to also become zero.

In the manner described above, the constant current source apparatus **10** can cause a constant current to flow to the load **200** because the complementary switching section **14** outputs the reference voltage V_{REF} in a case where a control signal indicating “on” is supplied from the external section. Furthermore, the constant current source apparatus **10** can cut off the flow of current to the load **200** because the complementary switching section **14** outputs the negative driving V_M in a case where a control signal indicating “off” is supplied from the external section. Accordingly, through the constant current source apparatus **10** configured as described above, a constant current flowing to the load **200** can be turned on or off by receiving logic signals having different operating voltages.

FIG. **2** shows a circuit configuration of a voltage control oscillator **210** according to the present embodiment. The negative FET **20** is provided with a resonant circuit **52** and an amplifier circuit **54**.

The resonant circuit **52** generates an oscillating signal having a frequency according to a control voltage V_{cont} supplied from a phase comparator, for example. The resonant circuit **52** passes resonance frequency components of the signal supplied from the amplifier circuit **54** and attenuates the other frequency components. Therefore, the resonant circuit **52** can generate the oscillating signal having a frequency according to the control voltage V_{cont} .

The amplifier circuit **54** amplifies the oscillating signal generated by the resonant circuit **52** and feeds the amplified signal back to the resonant circuit **52**. Specifically, the amplifier circuit **54** performs positive feedback amplification on the oscillating signal generated by the resonant circuit **52** and supplies the resonant circuit **52** with the thusly amplified signal. In other words, the amplifier circuit **54** functions as a negative resistor connected to an input/output junction of the resonant circuit **52**.

The resonant circuit **52** and the amplifier circuit **54** configured as described above can continue to output an oscillating signal having a frequency according to the control voltage V_{cont} . In other words, the resonant circuit **52** and the amplifier circuit **54** can perform an oscillating operation.

The resonant circuit **52** includes a positive resonance inductor **66**, a negative resonance inductor **68**, a positive resonance capacitor **70**, a negative resonance capacitor **72**, a positive variable capacitance diode **74**, and a negative variable capacitance diode **76**. The resonant circuit **52** outputs a noninverted oscillating signal from a first contact point **62**. Furthermore, the resonant circuit **52** outputs an inverted oscillating signal from a second contact point **64**.

The positive resonance inductor **66** is connected between the positive driving voltage V_P and the first contact point **62**. The negative resonance inductor **68** is connected between the positive driving voltage V_P and the second contact point **64**.

One end of the positive resonance capacitor **70** is connected to the first contact point **62** and the other end of the positive resonance capacitor **70** is connected to a cathode of the positive variable capacitance diode **74**. One end of the negative resonance capacitor **72** is connected to the second contact point **64** and the other end of the positive resonance capacitor **70** is connected to a cathode of the negative variable capacitance diode **76**. An anode of the positive variable capacitance diode **74** is connected to an anode of the negative variable capacitance diode **76**.

The positive variable capacitance diode **74** and the negative variable capacitance diode **76** receive the control voltage

6

V_{cont} supplied from the phase comparator at the anode-cathode junction. Capacitance of the positive variable capacitance diode **74** and the negative variable capacitance diode **76** is changed according to the control voltage V_{cont} received at the anode-cathode junction.

The resonant circuit **52** described above changes the resonance frequency of the impedance between the first contact point **62** and the second contact point **64** according to the supplied control voltage V_{cont} . Accordingly, the resonant circuit **52** can output a differential oscillating signal having a frequency according to the supplied control voltage V_{cont} .

The amplifier circuit **54** includes the constant current source apparatus **10**, a positive capacitor **82**, a negative capacitor **84**, a first amplification transistor **86**, a negative bias resistor **88**, a second amplification transistor **90**, and a positive bias resistor **92**. The amplifier circuit **54** receives the noninverted oscillating signal from the first contact point **62**, performs inverted amplification, and feeds the amplified signal back to the second contact point **64**. Furthermore, the amplifier circuit **54** receives the inverted oscillating signal from the second contact point **64**, performs inverted amplification, and feeds the amplified signal back to the first contact point **62**.

The amplifier circuit **54** outputs the noninverted oscillating signal from a positive oscillating signal output end **94**. Furthermore, the amplifier circuit **54** outputs the inverted oscillating signal from a negative oscillating signal output end **96**.

Because the constant current source apparatus **10** has generally the same configuration and function as the constant current source apparatus **10** shown in FIG. **1**, the following description includes only points of difference and omits identical points. The constant current source apparatus **10** causes a predetermined current I_c to flow to the negative driving voltage V_M . Specifically, the constant current source apparatus **10** sets the total value of the current flowing to the negative driving voltage V_M from the first contact point **62** via the amplifier circuit **54** and the current flowing to the negative driving voltage V_M from the second contact point **64** via the amplifier circuit **54** as the fixed value I_c .

The constant current source apparatus **10** receives from the external section a control signal instructing the voltage control oscillator **210** to perform oscillation or stop oscillation. In a case where a command signal instructing the voltage control oscillator **210** to perform oscillation is received from the external section, the constant current source apparatus **10** causes current to flow. In a case where a command signal instructing the voltage control oscillator **210** to stop oscillation is received from the external section, the constant current source apparatus **10** cuts off the current.

The positive capacitor **82** is serially connected between the first contact point **62** above the resonant circuit **52** and the positive oscillating signal output end **94**. The positive capacitor **82** can cut off the continuous current flowing from the first contact point **62** to the positive oscillating signal output end **94**.

The negative capacitor **84** is serially connected between the second contact point **64** above the resonant circuit **52** and the negative oscillating signal output end **96**. The negative capacitor **84** can cut off the continuous current flowing from the second contact point **64** to the negative oscillating signal output end **96**.

The first amplification transistor **86** receives at a base thereof the noninverted oscillating signal output from the first contact point **62** of the resonant circuit **52**. The negative bias resistor **88** supplies a bias voltage to the base of the first amplification transistor **86**. The first amplification transistor **86** then feeds back to the second contact point **64** of the

resonant circuit **52** a current obtained by amplifying the received noninverted oscillating signal.

The first amplification transistor **86** may be an npn transistor, for example. In such a case, the base of the first amplification transistor **86** is connected to a wire between the positive oscillating signal output end **94** and the positive capacitor **82**, a collector of the first amplification transistor **86** is connected to the second contact point **64**, and an emitter of the first amplification transistor **86** is connected to the constant current source apparatus **10**.

The first amplification transistor **86** described above functions as a switch connected between the second contact point **64** and the constant current source apparatus **10**. In other words, the first amplification transistor **86** is on in a case where the voltage between the positive oscillating signal output end **94** and the positive capacitor **82** is greater than a prescribed voltage and is off in a case where the voltage between the positive oscillating signal output end **94** and the positive capacitor **82** is less than or equal to the prescribed voltage.

The second amplification transistor **90** receives at a base thereof the inverted oscillating signal output from the second contact point **64** of the resonant circuit **52**. The positive bias resistor **92** supplies a bias voltage to the base of the second amplification transistor **90**. The second amplification transistor **90** then feeds back to the first contact point **62** of the resonant circuit **52** a current obtained by amplifying the received inverted oscillating signal.

The second amplification transistor **90** may be an npn transistor, for example. In such a case, the base of the second amplification transistor **90** is connected to a wire between the negative oscillating signal output end **96** and the negative capacitor **84**, a collector of the second amplification transistor **90** is connected to the first contact point **62**, and an emitter of the second amplification transistor **90** is connected to the constant current source apparatus **10**.

The second amplification transistor **90** described above functions as a switch connected between the first contact point **62** and the constant current source apparatus **10**. In other words, the second amplification transistor **90** is on in a case where the voltage between the negative oscillating signal output end **96** and the negative capacitor **84** is greater than the prescribed voltage and is off in a case where the voltage between the negative oscillating signal output end **96** and the negative capacitor **84** is less than or equal to the prescribed voltage.

The amplifier circuit **54** described above can perform inverted amplification on the noninverted oscillating signal output from the first contact point **62** of the resonant circuit **52** and feed the amplified signal back to the second contact point **64** of the resonant circuit **52**. In addition, the amplifier circuit **54** can perform inverted amplification on the inverted oscillating signal output from the second contact point **64** of the resonant circuit **52** and feed the amplified signal back to the first contact point **62** of the resonant circuit **52**. Therefore, the resonant circuit **52** and the amplifier circuit **54** can perform positive feedback amplification on the differential oscillating signal having a prescribed frequency.

The voltage control oscillator **210** described above can output an oscillating signal in a case where a command signal instructing performance of oscillation is received from the external section because the constant current source apparatus **10** continuously causes the constant current to flow to perform the amplification operation on the oscillating signal. Furthermore, the voltage control oscillator **210** can stop oscillation in a case where a command signal instructing stoppage of oscillation is received from the external section because the

constant current source apparatus **10** cuts off the flowing current to stop the amplification operation of the oscillating signal.

While the embodiment of the present invention has been described, the technical scope of the invention is not limited to the above described embodiment. It is apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiment. It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

What is claimed is:

1. A constant current source apparatus, comprising:

a complementary switching section that selectively outputs a reference voltage or a driving voltage according to a control signal; and

a constant current source circuit that causes a constant current determined by the reference voltage to flow to a load in a case where the reference voltage is received from the complementary switching section and cuts off the current flowing to the load in a case where the driving voltage is received from the complementary switching section,

wherein the complementary switching section further includes:

a first FET in which one of either a source or a drain is connected to the driving voltage, the other source or drain is connected to an output end of the complementary switching section, and a gate receives the voltage according to the control signal;

a second FET that switches to an opposite polarity of the first FET, in which one of either a source or a drain is connected to the reference voltage, the other source or drain is connected to the output end of the complementary switching section, and a gate receives the voltage according to the control signal;

a bias section that supplies to a gate of the first FET and the second FET a first voltage that turns the first FET on and turns the second FET off or a second voltage that turns the first FET off and turns the second FET on; and

a switching circuit that switches between supplying the first voltage to the gate of the first FET and the second FET and supplying the second voltage to the gate of the first FET and the second FET according to the control signal.

2. The constant current source apparatus according to claim **1**, wherein the constant current source circuit includes a current mirror circuit that causes the current determined by the reference voltage received from the complementary switching section to flow to the load.

3. The constant current source apparatus according to claim **2**, wherein the current mirror circuit includes:

a diode-connected control transistor; and

a current source transistor that causes a current flowing to the load to flow to a collector-emitter junction thereof and in which a base thereof is connected to a base of the control transistor.

4. The constant current source apparatus according to claim **3**, wherein the current mirror circuit further includes:

a first bias transistor that is connected between an emitter of the control transistor and the driving voltage and generates a bias determined by the reference voltage received from the complementary switching section; and

a second bias transistor that is connected between an emitter of the current source transistor and the driving volt-

age and generates a bias determined by the reference voltage received from the complementary switching section.

5. The constant current source apparatus according to claim 4, wherein the first bias transistor and the second bias transistor become open in a case where the driving voltage is received from the complementary switching section.

6. The constant current source apparatus according to claim 1, wherein the complementary switching section further includes a protection resistor connected between an output end of the complementary switching section and the driving voltage.

7. The constant current source apparatus according to claim 1, further comprising a bandgap reference circuit that generates the reference voltage.

8. The constant current source apparatus according to claim 1, wherein the constant current source circuit is connected to an output end of the complementary switching section.

9. The constant current source apparatus according to claim 1, wherein the load is connected to the constant current source circuit.

10. The constant current source apparatus according to claim 1, wherein the reference voltage is received at the constant current source circuit from the complementary switching section via an output end of the complementary switching section.

11. The constant current source apparatus according to claim 1, wherein the driving voltage is received at the constant current source circuit from the complementary switching section via an output end of the complementary switching section.

12. The constant current source apparatus according to claim 1, wherein the constant current source circuit, connected to an output end of the complementary switching section, causes the constant current determined by the reference voltage to flow to the load, connected to the constant current source circuit, in a case where the reference voltage is received from the complementary switching section via the output end, and cuts off the current flowing to the load in a case where the driving voltage is received from the complementary switching section via the output end.

13. The constant current source apparatus according to claim 1, wherein the control signal is supplied from an external section.

14. The constant current source apparatus according to claim 13, wherein the complementary switching section outputs the reference voltage in a case where the control signal indicating ON is supplied from the external section.

15. The constant current source apparatus according to claim 13, wherein the complementary switching section outputs the driving voltage in a case where the control signal indicating OFF is supplied from the external section.

16. A current control method comprising:

selectively outputting, by a complementary switching section, a reference voltage or a driving voltage according to a control signal, wherein the complementary switching section includes: a first FET in which one of either a source or a drain is connected to the driving voltage, the other source or drain is connected to an output end of the complementary switching section, and a gate receives the voltage according to the control signal; a second FET that switches to an opposite polarity of the first FET, in which one of either a source or a drain is connected to the reference voltage, the other source or drain is connected to the output end of the complementary switching section, and a gate receives the voltage according to the control signal; a bias section that supplies to a gate of the first FET and the second FET a first voltage that turns the first FET on and turns the second FET off or a second voltage that turns the first FET off and turns the second FET on; and a switching circuit that switches between supplying the first voltage to the gate of the first FET and the second FET and supplying the second voltage to the gate of the first FET and the second FET according to the control signal;

causing a constant current determined by the reference voltage to flow to a load in a case where the reference voltage is received from the complementary switching section; and

cutting off the current flowing to the load in a case where the driving voltage is received from the complementary switching section.

* * * * *